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To Mr. L.A. Leeyus
Manager - Civil Design
Design & Development-Gen.

Attn: Mr. B. Lewicki, H17 B27

CRYSTAL FALLS GS
DAM REHABILITATION

P.K. Mukherjee and G.M. Kidd

A preliminary investigation of the quality of concrete aggregates, as well as, the performance of ready-mix plants in the area was carried out. The transit time between the approved ready-mix plant in North Bay and the Crystal Falls site was longer than normal. An evaluation of the concrete quality was therefore conducted to determine any adverse effect on the properties of the fresh and hardened concrete due to the prolonged transit time. Modifications to the concrete mix and field inspection program are recommended for the rehabilitation work.

1.0 INTRODUCTION

This report gives the details of the work carried out for evaluation of concrete aggregates (coarse and fine) and that of the effects of extended transit time on the concrete in the field. This provided a basis for assessing the quality of the concrete proposed for the rehabilitation of the dam.

2.0 AGGREGATE EVALUATION

A preliminary investigation of aggregate sources and inspection of ready-mix plants in the area were carried out in March 1986 (see Appendix A). As a result of the investigation and subsequent consultations with the Ontario Ministry of Transportation and Communication (MTC), the aggregates stock pile at Premier Ready-Mix Co. was provisionally approved.

job	file	date	report no.
740642-115-575	842.3 CRYS	August 26, 1986	86-226-K

Samples of the aggregates were obtained for limited conformatory testing. The test results are attached in Appendix B. The coarse aggregate sample contained a few friable particles, but the amount was within acceptable limit (Ontario Hydro Spec. M-182). Tests by MTC indicated higher than normal abrasion loss. The overall quality of the coarse aggregates is not the best, but acceptable for the job.

3.0 CONCRETE QUALITY OF PREMIER READY-MIX PLANT, NORTH BAY

The above ready-mix plant was again visited on June 26, 1986. The deficiencies cited in the earlier inspection (Appendix A) have been rectified. The concrete for underwater tremie work at Crystal Falls GS was being produced at the time of the visit. Three truck loads of concrete were delivered to the job site. The mix proportions were as follows:

Cement (Type 10)	370 kg/m^3* (Lake Ontario Cement)
Sand	730 kg/m^3
Coarse Aggregate (20 mm)	1075 kg/m^3
Water	140 kg/m^3
Water Reducer (Eucon)	250 ml/100 kg of Cement
Air Ent. Admixture	62.5 ml/m^3

The fresh concrete properties of load #1 were checked at the ready-mix plant, and also at the job site. The remaining two loads were checked at the job site only. This provided an opportunity to determine the effect of travel time (about one hour) on the properties of the concrete. The test results are shown in Table 1. As expected, a loss in the air content and slump was noted due to the prolonged transit time at the agitating speed (<5 rpm), the loss being 1.5% for air and 90 mm for slump. About 10 to 15% additional amount of water was added at the job site to compensate for the loss of workability. This increased the water to cement ratio (w/c) from 0.37 to 0.43. A set of cylinders was made at the ready-mix plant from load #1. The cylinders were tested by Trow Ltd. of North Bay and the results are enclosed in Appendix C. The twenty-eight days strength exceeded the specified strength. It may be noted that these cylinders were made at the ready-mix plant, prior to adding of extra water to the mix in the field.

* The actual measurements were taken in lb/m^3.

Data from our previous laboratory tests on Type 10 cement concrete indicate (see Figure 1) that an increase in water to cement ratio (w/c) from 0.37 to 0.43 will reduce the strength by about 15%. Since the mix contained sufficient cement, an increase in the amount of mix water by about 15% would still maintain the strength above the specified value.

4.0 WATER SAMPLE

It was observed that the mix water is being obtained from a well nearby. Samples of the water were tested in the laboratory for chloride, pH and solids (see Table 2). Since the level of chloride and solids was slightly higher than that normally acceptable for concrete, strength tests on mortar were carried out and compared with those made with the laboratory water (see Table 2). A reduction in strength by about 2% was noted. This is within the acceptable limit of maximum 10% (see CSA A23.1-M77, Clause 4.2).

5.0 REMARKS

Based on the tests and above observations, the following remarks are made for the dam rehabilitation work:

5.1 The aggregates and the mix water are acceptable for the job.

5.2 The prolonged transit time (over one hour) will reduce the air content by about 2%, and a significant loss in workability will occur. In order to compensate for the loss in air, the air content at the ready-mix plant should be increased by two percentage points above the specified limit ($6 \pm 1.5\%$). The cement content should be maintained high enough to compensate for any loss in strength due to extra water being added at the job site to increase the workability. The other alternative would be to consider using super-plasticizer (SP) at the job site for maintaining the workability.

5.3 The tremie concrete contained a water reducing (WN) admixture along with an air-entraining agent. Use of a retarding type (WR) admixture is recommended for the concrete proposed for the rehabilitation work.

5.4 A continual inspection of the concrete quality during the progress of the rehabilitation work is strongly recommended.

Approved by:

T.W. Klym
Manager
Civil Research Department

Submitted by:

P.K. Mukherjee
Senior Engineer
Concrete Technology Section

G.M. Kidd
Concrete Control Superintendent
Concrete Control

Reviewed by:

G.S. Kellay
Supervising Engineer
Concrete Technology Section

PKM/GMK:mb

Table 1

CRYSTAL FALLS GS

Properties of Fresh Concrete at
Ready-Mix Plant and at Job Site

Load No. and (Quantity)	Location of Test	Air Content %	Slump mm (in)	Temp °C
1 ($5.5\ m^3$)	a) At Plant	7.0	170(7)	18
	b) At Site	5.5	80(3-1/4)*	18
2 ($5.5\ m^3$)	At Site	4.0	90(3-3/4)*	20
3 ($5.0\ m^3$)	At Site	6.0	140(5-1/2)	17

(*) 25 to 30 gallons of water were added after the test.

Table 2

CRYSTAL FALLS GS

Tests on Water Samples

Sample No	pH	Solids mg/litre	Chloride (Cl) mg/litre	Compressive Strength Ratio (%) Test Sample / Control Sample (*)
1	8.0	688	203	99.1 (7 days) 97.8 (28 days)
2	-	-	256	-

(*) Laboratory Serial No: 13750 (Control) and 13751 (Test) for mortar strength tests.

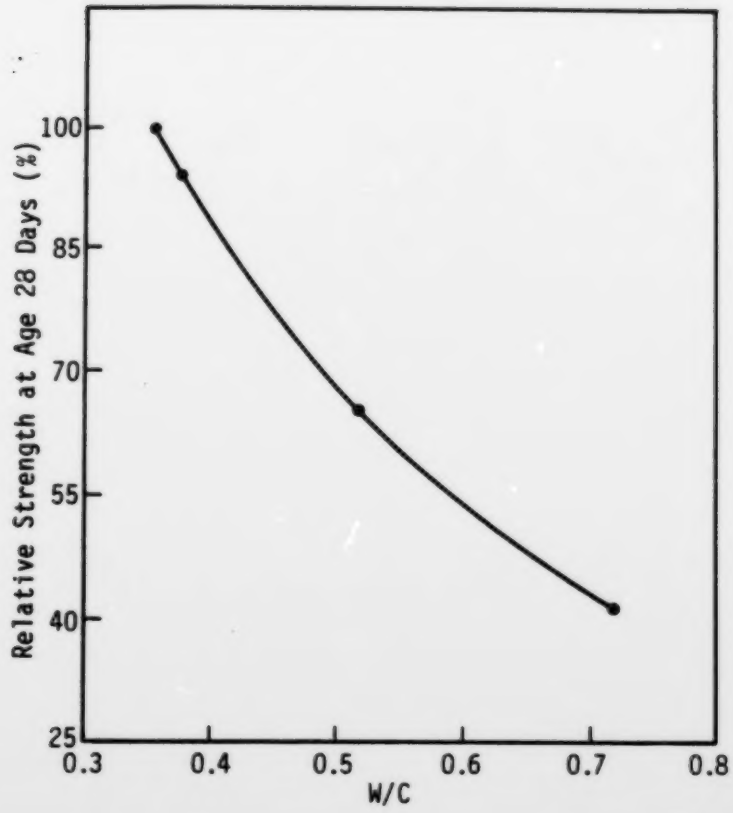

FIGURE 1

CRYSTAL FALLS GS

WATER TO CEMENT RATIO (W/C) VS RELATIVE STRENGTH OF TYPE 10 CEMENT CONCRETE, BASED ON LABORATORY TEST DATA REPORTED IN REPORT NO: S75-32K (TABLE 1)

APPENDIX A

Crystal Falls GS

Evaluation of Ready-Mix Plant Facilities
and Sources of Concrete Aggregates

ENN LAAGUS April 3, 1986

Garson, Ontario 842.3(T)

Crystal Falls Ready Mix Supplier

On March 12-13, the writer and Mr. J. DeBoer visited the facilities of Rainbow Ready Mix in North Bay and Sturgeon Falls and of Premier Concrete in North Bay. The purpose of this visit was to examine the ready-mix plants and evaluate them as possible suppliers of ready mix concrete for the Crystal Falls project for 1986.

None of the three plants inspected met all the evaluation criterias for supplying an Ontario Hydro project; however, with some maintenance and implementation of quality control procedures, all plants can be made acceptable. The deficiencies were reported verbally to the respective company representatives at the time and are detailed in the attached inspection reports.

As part of the evaluation program, samples of aggregates are obtained and tested for conformance. At the Premier plant, there are 40,000 tonnes of coarse and 40,000 tonnes of fine aggregate in storage at the yard. Samples of these materials were obtained and are presently being evaluated at our laboratory at the Kipling Complex.

The Rainbow Plant at Sturgeon Falls did not have any fine aggregate in storage and the limited amount of coarse aggregate was supposedly of the same source as the North Bay plant and was not sampled.

At the Rainbow Plant in North Bay there were two types of coarse aggregate - one from their Sudbury pit which is not MTC approved and local material which is presently being evaluated by MTC and is to be processed at the plant. At the time of our visit, the Sudbury coarse aggregate material was sampled together with the fine aggregate. The understanding at the time was that as soon as the local material was processed, a sample would be shipped to the Kipling Complex for testing.

A few days later two sample bags of coarse material was received from Rainbow. Upon inspection, it was determined that this was not the processed material from the stockpile at the North Bay yard. It was later confirmed by telephone that the material shipped was from a third source a few miles north of North Bay and that the material was reported to be MTC approved.

Rainbow has, therefore, three coarse aggregate sources:

(a) from their Sudbury pit - not approved by MTC;

(b) their block plant in North Bay - presently being evaluated by MTC;

(c) a source north of North Bay - not inspected by us but reportedly MTC approved.

In view of the many sources available, we feel that it is possible that some confusion may occur at batching, resulting in uncertainty in what material is actually used. One source is known to be not acceptable, one is in the approval process and the third has not been inspected by us.

We therefore feel that Premier should be selected on the basis of certainty of source of supply of coarse aggregate. However, in order that Premier meet the acceptance criteria, the following is required:

(1) calibration of weigh scales;

(2) water meter installation and calibration;

(3) installation of admixture dispensers;

(4) quality control equipment (slump cone, air meter, etc);

(5) installation of moisture meter in fine aggregate bin;

(6) submission of proposed mix design.

We are appreciative of the fact that Rainbow's plant in Sturgeon Falls is near the site and that the North Bay plant can be used as back-up, however; we do not expect that Premier's plant (which has gone extensive renovation) will not be able to produce the amounts required, and the distance from North Bay to Crystal Falls is not excessive.

ENN LAAGUS

April 3, 1986

We are presently conducting tests on the aggregates from Premier and should have the results in a couple of months (the alkali-reactivity tests are time dependent). We suggest that acceptance be conditional on the outcome of these tests.

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R. Caratin
Engineer
Concrete Technology Section
Civil Research Department
(Ext 122+7080)

RC:SER

Enc

cc D. McIntyre
G.M. Kidd/A.B. George

APPENDIX B

Crystal Falls GS

Test Results of Aggregates

Sample No: S-7509 and S-7510
and Petrographic Analysis of
Coarse Aggregates (S-7510)

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concrete aggregate test report

project: Crystal Falls GS, Ready Mix Plant Eval		date: June 10, 1986	
aggregate: Crushed Gravel		file no.: 842.21	report no.: SE86-6-H
submitted by: H. Caratin	quantity: 1 Bag	charge to: 740642-115	
source: Premier Ready Mix, North Bay		aggregate no.'s: S-7510	
origin:			

sieve analysis

	sieve size											
	mm	40	28	20	14	10	5	2.5	1.25	0.63	.315	.160	pan
	in no.	1 1/2	1	3/4	1/2	3/8	no. 4	8	16	30	50	100	
combined % passing													
% passing			100	99.5	77.8	48.8	4.4						
% retained			0	0.5	22.5	28.2	44.4						

	relative density			absorp. %	organic no.	pass 80 um %	soundness 5 cycle loss %	petro number (PN)	abrasion	
	oven dry	sat surf dry	apparent						wear	grading
fine aggregate										
coarse aggregate	2.67	2.69	2.71	0.48				114		

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File 842.21	Official Record
File 842.21(P)	

approved by: P. Mukherjee

submitted by: D.G. Wilkinson D.G. Wilk

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research division

concrete aggregate test report

project: Crystall Falls GS, Ready Mix Plant Eval.		date: June 10, 1986	
aggregate: Sand		file no.: 842.21	report no.: SE86-5-H
submitted by: H. Caratin	quantity: 1 Bag	charge to: 740642-115	
source: Premier Ready Mix, North Bay		aggregate no.'s: S-7509	
origin:			

sieve analysis

	sieve size											
	mm	40	28	20	14	10	5	2.5	1.25	0.63	.315	.160	mm
	inch	1 1/2	1	3/4	1/2	3/8	no. 4	8	16	30	50	100	
combined % passing													2.45
% passing						100	96.4	89.3	78.0	58.0	26.1	7.4	
% retained						0	3.6	7.1	11.3	20.0	31.9	18.7	

	relative density			absorp %	organic no.	pass 80 um %	soundness 5 cycle loss %	petro number (PN)	abrasion	
	oven dry	sat surf dry	apparent						wear	loss %
fine aggregate	2.65	2.66	2.68	0.50	1	1.18		-		
coarse aggregate										

Distribution

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File 842.21 Official Record
File 842.21 (P)

approved by: P. Mukherjee

submitted by: D.G. Wilkinson

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Ontario Hydro
Research Division

petrographic analysis report — concrete aggregate

PROJECT: Crystal Falls		REQUESTED BY: H. Caratin	SAMPLE IDENTIFICATION: S — 7510 P — 3740
SUPPLIER: Premier Redi-Mix, North Bay			DATE: June 5, 1986
ORIGIN: Premier Redi-Mix stockpiles			CHARGE NO.: 740642-115-507
FORM: Crushed Aggregate	DATE SAMPLED: March 12/86	SAMPLED BY: H. Caratin	FILE NO.: 842.4TRAS-N / REPORT NO.: SB86-2-H

PETRO NO. MULTI FACTOR	TYPE NO.	AGGREGATE TYPE		SIEVE SIZE (mm)	— 40		40 — 28		28 — 20		20 — 14		14 — 10		10 — 5	
				% RETAINED							23.6		29.6		46.8	
				NO OF PIECES							200		211		210	
				% OF FRACTION (BY COUNT)	%	PETRO NO.	%	PETRO NO.	%	PETRO NO.	%	PETRO NO.	%	PETRO NO.	%	PETRO NO.
X1	1	CARBONATES	(HARD)													
	20	CARBONATES	(SLIGHTLY WEATHERED)													
	2	CARBONATES	(HARD, SANDY)													
	21	CARBONATES	(MEDIUM HARD, SANDY)													
	23	CARBONATES CRYSTALLINE	(HARD)													
	8	GRANITE — DIORITE	(HARD)								34.0	34.0	34.1	34.1	44.9	44.9
	4	GNEISS	(HARD)								58.0	58.0	53.1	53.1	39.4	39.4
	7	VOLCANIC	(HARD, SL. WEATHERED)													
	5	QUARTZITE	(COARSE GRAINED)								4.0	4.0	3.3	3.3	1.3	1.3
	3	SANDSTONE	(HARD, MED.HARD)													
	6	GREYWACKE — ARKOSE	(HARD)													
	9	TRAP	(HARD)													
		GABBRO — ULTRABASICS	(HARD)								1.5	1.5	3.8	3.8	6.7	6.7
X3	42	CARBONATES	(DEEPLY WEATHERED)													
	41	CARBONATES	(SOFT, SANDY)													
	40	CARBONATES	(SOFT, OR SL. SHALY)													
	24	CARBONATES CRYSTALLINE	(SLIGHTLY WEATHERED)													
	27	GRANITE — DIORITE	(BRITTLE)								1.0	3.0	0.9	2.7	4.8	14.4
	25	GNEISS	(BRITTLE)								1.0	3.0	3.8	11.4	2.4	7.2
	28	VOLCANIC	(SOFT)													
	47	QUARTZITE	(FINE GRAINED)												0.5	1.5
	52	ENCRUSTATIONS														
		CHERT 25 — 75%	(UNLEACHED)													
		CHERT > 75%	(UNLEACHED)													
											0.5	1.5	0.5	1.5		
X6	43	CARBONATES	(CLAYEY OR SHALY)													
	44	CARBONATES	(OCHREOUS)													
	49	CARBONATES CRYSTALLINE	(SOFT)													
	51	GRANITE — DIORITE	(FRIABLE)													
	50	GNEISS	(FRIABLE)										0.5	3.0		
	48	VOLCANIC	(VERY SOFT, POROUS)													
	46	SANDSTONE	(SOFT, FRIABLE)													
	55	SCHIST	(SOFT)													
		ARGILLITE														
		CHERT 25 — 75%	(LEACHED)													
		CHERT > 75%	(LEACHED)													
		SILTSTONE														
X10	62	CLAY														
	61	SHALE														
	60	OCHRE														
	63	VOLCANIC	(DECOMPOSED)													
		CARBONATES	(DECOMPOSED)													
	TOTALS										100	105.0	100	112.9	100.0	115.4

PETROGRAPHIC NUMBER	BY FRACTION				105	113	115
	TOTAL SAMPLE — WEIGHTED ACCORDING TO GRADING						112

REMARKS: This sample is petrographically acceptable for use in frost resistant concrete.

APPROVED BY: T.G. Camble

SUBMITTED BY: J.B. Williams

DISTRIBUTION: H. Caratin, R. Koopmans, D.G. Wilkinson, R.A. Rankin, Official Record, J.B. Williams, Original to R.A. Rankin

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APPENDIX C

Crystal Falls GS

Compressive Strength Test Data
from Trow Ltd. North Bay, Ontario

Trow Ltd
Consulting Engineers

North Bay Branch: Trow Ltd.
R. R. #4
Site 2, Compartment 9
North Bay, Ontario
P1B 8G5
(705) 472-2220

July 3, 1986

COMPRESSIVE STRENGTH CYLINDER TEST REPORT

LAB. NO.	TEST NO.	CYL. NO.	DATE CAST	DATE RECEIVED IN LAB	DATE TESTED	* T.O.F.	DENSITY kg/m³	SPECIFIED 28 DAY STRENGTH	7 DAY STRENGTH MPa	28 DAY STRENGTH MPa	DAY STRENGTH MPa
3545	1	1L	June 26	June 27	July 3		2320	20 MPa.	26.6		
3546		2L	"	"	July 24		2315	"		33.4	
3547		3L	"	"	July 24		2315	"		33.7	

NOTE: SUFFIX "L" DENOTES LABORATORY CURED . . . SUFFIX "F" DENOTES FIELD CURED *TYPE OF FRACTURE – REQUIRED WHEN CYLINDER FAILS TO MEET SPECIFIED STRENGTH AT 28 DAYS

CONTRACTOR: Ontario Hydro

PROJECT: Crystal Falls Dam, Crystal Falls, Ontario

LOCATION ON STRUCTURE: Cofferdam

CONCRETE SUPPLIER: Premier Concrete

CYLINDERS CAST BY: P. K. Mukherjee — OF: Ontario Hydro

TIME MIXER CHARGED: 8:40 AM. — TIME CYLINDERS CAST: 9:00 AM.

TYPE OF MOULD USED: Metal — MEASURED SLUMP: 7", (180mm.)

TEMP. OF CONCRETE: 18°C — AIR TEMPERATURE: 15°C

SPECIFIED AIR %: 5% to 8% — MEASURED AIR %: 7.0%

WATER ADDED ON THE JOB: --- — BY WHAT AUTHORITY: ---

TRUCK NO.: 2302 — LOAD NO.: 1

NOM. SIZE OF AGG.: 20mm. — DRUM COUNT REVS.: ---

TYPE OF ADMIXTURE: W.R.A. — AIR ENT. AGENT: A.E.A.

INITIAL 24 HOUR CURING TEMPERATURES — MAXIMUM: --- MINIMUM: ---

MATERIALS USED PER CUBIC METRE

CEMENT: — WATER:

COARSE AGG.: — FINE AGG.:

NAME OF ADMIXTURE: — NAME OF AIR ENT. AGENT:

REMARKS: Tremie Concrete

WE HEREBY CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH CAN3-A23. 1M77 FOR THAT PORTION OF THIS TESTING PERFORMED BY THIS COMPANY.

DISTRIBUTION: Ontario Hydro
Att'n: Mr. P. K. Mukherjee

Premier Concrete
Att'n: Mr. L. Hoffman

JOB NO. N861027M

7 DAY RESULTS J.W.C.

28 DAY RESULTS J.W.C.

___ DAY RESULTS